ELDANA BORER RESEARCH: THE ROLE OF THE BIOCONTROL INSECT UNIT

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Abstract

Since October 1988, the new biocontrol centre's insect unit has been used for all large scale insect rearing for research purposes. Fundamental to the programme is the culture of *Eldana saccharina* Walker (Lepidoptera: Pyralidae), the major pest in southern African sugarcane. This is required for:

- rearing of candidate parasitoids, including material for large scale field releases
- varietal resistance studies
- behavioural studies, including pheromones
- biochemical investigations, including kairomones
- bioassays for pathogen and insecticidal research.

Mechanisation and hygienic streamlining of procedures have permitted increased efficiency and more reliable production of the insect cultures. At the same time production costs were cut by reducing staff and using materials more economically.

Introduction

The use of insects reared specifically for research purposes, pest control programmes and various insect products is not a new concept. The Chinese have been rearing silkworms for at least 7 000 years; also the lac insect, *Laccifer lacca* Kerr for several thousand years, as have the Indians (Singh and Moore, 1985). Today, insects are still reared for the same medicinal purposes as they were from 31 BC to AD 1578 (Singh and Moore, 1985). Entomological literature since the early 1900s regularly contained papers on the rearing of insects for a variety of purposes (Singh, 1977). As early as 1908, entomologists were publishing papers on the rearing of insects on artificial diets (Singh and Moore, 1985).

By the time *Eldana saccharina* Walker was a major pest of South African sugarcane, laboratory rearing methods had been developed for stalk borers such as *Ostrinia nubilalis* (Hubner) by Bottger (1942), *Chilo suppressalis* (Walker) by Ishii (1952) and *Pectinophora gossypiella* (Saunders) by Vanderzant and Reiser (1956). A most important contribution to the laboratory rearing of lepidopterous stalk borers was the development of the wheat germ based diet by Adkisson *et al.* (1960) and Berger (1963). This was the recipe on which Atkinson (1978) based the first successful artificial diet for the mass production of *E. saccharina* in South Africa. The reasons given for his approach, viz. "a mass rearing method capable of meeting the demands for laboratory studies on predation, rearing parasites, adult trapping and pheromone research, cohort planting and artificially infested insecticide trials" still stand. However, his recipe and rearing methods are now not cost effective, as the subsequent development of the *E. saccharina* biocontrol programme since 1981 has revealed.

In addition, developments between 1981 and 1988 in the prefabricated biocontrol unit supported the views by Singh (1988) that "insect rearing, as a scientific discipline, is a fundamental requirement in the development of modern experimental entomology and insect control practices", because it ensures a reliable and quality controlled supply of required insect stages. With the development of the custom-built insect unit at the Experiment Station in 1988 (Anon., 1988), came the aim of providing a reliable supply of high quality insects.

It is the aim of this paper to show how successful insect rearing has been achieved, and how the more disciplined approach to insect rearing (Conlong, 1989) has increased not only the productivity of the Entomology department, but also of other departments using the insects being reared. In addition, it has reduced wastage and cut costs, thereby adding value to the Experiment Station's efforts at controlling *E. saccharina.*

Review of Progress

Insect production

Eldana saccharina

Table 1 compares the larval yield and extent of microbial contamination of the final few daily mixes in the old insectary, with the 1989, 1990 and 1991 mixes in the new unit.

Table 1

A comparison of the larval yield (per multicell tray) and extent of microbial contamination of the final daily *Eldana saccharina* laboratory culture mixes in the old insectary, and the 1989, 1990 and 1991 mixes in the new insect unit

Insectary	Year	Total trays inoculated	Mean yield (*E. saccharina* per tray)	% Microbial contamin.
Old	1988	285	17,4	48,4
New	88-89	51 366	29,3	0,9
	89-90	61 401	30,0	3,3
	90-91	87 815	36,0	8,9
	3-11/91	61 573	30,0	6,8

It is evident that the yield of insects per tray from the culture increased by 70% after moving to the new unit, and that it has been remarkably consistent since then. Since the move, microbial contamination has been negligible compared with the contamination level in the old insectary (48,8%). Since November 1990, very rigorous contamination checks have been continuously implemented, where any contaminated tray was removed from the larval growth rooms. Under this continuous, intensive monitoring, the contamination levels have never exceeded 10%.

Goniozus natalensis Gordh. (Hymenoptera: Bethylidae)

Table 2

A comparison of the production of the *Goniozus natalensis* laboratory cultures for the last four months in the old insectary, and the first three years in the new insect unit

Insectary	Year	Total adults inoculated	Total offspring emerged	Mean annual rate of increase
Old	1988	496	256	0,3
New	1989	239 268	734 358	3,2
	1990	186 785	288 603	1,2
	1991	2 895	2 727	0,9

When the *G. natalensis* culture was moved from the old insectary, it was very low; only 256 offspring were obtained from a total of 496 adults which were inoculated during the last four months of their stay (Table 2). In its first year in the new unit a 3,2 times rate of increase in the culture was achieved. During 1990 the rate of increase was 1,2. This drop was related to a period of high contamination experienced in its host culture during the latter part of 1990. While the *G. natalensis* culture was subjected to this stress, it was infected by a microsporidian which markedly reduced its fecundity. Despite many attempts to reduce the infection, the parasitoid culture did not recover and in 1991 it was terminated.

Paratheresia claripalpis Wulp. (Diptera: Tachinidae)

Table 3 shows that when the *P. claripalpis* culture was moved into the new unit a two fold increase in parasitoid pupal recovery was obtained, and 20% more parasitoid adults emerged from the pupae obtained. These increased levels of production have been maintained during the period the culture has been in the new unit.

Table 3

A comparison of the production of the *Paratheresia claripalpis* laboratory culture for the last four months in the old insectary, and the first three years in the new insect unit

Insectary	Year	Total host larvae inoculated	Total parasitoid pupae recovered	Mean % recovered	Total parasitoid adults emerged	Mean % emerged
Old	1988	79 000	29 920	38,0	14 806	51,8
New	1989	192 885	157 207	81,3	123 795	75,4
	1990	227 100	178 124	77,3	128 399	69,8
	1991	176 640	131 269	73,9	90 623	66,4

Xanthopimpla stemmator Thunb. (Hymenoptera: Ichneumonidae)

Table 4

A comparison of the production of the *Xanthopimpla stemmator* laboratory culture for the last six months in the old insectary, the three month transition period, and the first three years in the new insect unit

Insectary	Year	Total host pupae used	Total parasitoids emerged	Mean % emergence
Old	1988	95 088	5 760	6,2
	1989	17 422	1 748	6,6
New	1989	137 339	30 931	22,0
	1990	195 722	37 586	19,5
	1991	182 797	59 397	34,4

The *X. stemmator* culture showed a similar increase when moved into the new unit (Table 4). In the old insectary, a six per cent mean emergence (or parasitism) rate was attained. During the first three months in the new unit, using the same rearing method, a 22% emergence of parasitoids was attained. By modifying the rearing procedure to take better account of the biology of *X. stemmator*, the mean emergence rate was increased to 34,4% in 1991.

Users and the results of their work

Ever since *E. saccharina* and parasitoids have been reared at the Experiment Station, the insects produced have been used in various trials, the results of which have been written up in papers, dissertations and theses, and have been presented at national and international congresses as posters and/or verbal presentations (Table 5).

Table 5

The numbers of published papers, congress verbal and poster presentations, dissertations and theses produced using results obtained from insects reared in the entomology laboratories since the first *E. saccharina* culture was established in 1977. The departments and sections using the insects are also listed

Year	No. of publ. papers	No. of verbal present.	No. of poster present.	No. of theses etc.	Departments responsible
77–80	4	2	0	0	Entomology
81–87	15	4	3	0	Entomology Plant Breed.
88–90	13	3	2	2	Entomology Plant Breed. Nematology Basic Res. Insect Path. PPRI

Cost reduction

In Table 6, the staff complement of each insect culture and the cost to produce one individual of each insect species is shown for the old and new buildings. The cost per insect has been calculated from the basic salaries of the staff involved in the particular culture and the recurrent running costs of the same culture. In compiling these, current costs have been compared with those of the equivalent culture, at June 1991 prices and salaries, but as if running at peak production in the old biocontrol insectary.

Table 6

A comparison of the insect culture staff complements and relative costs to produce one individual of each insect culture in the old and new biocontrol insect units

Insect culture	Old unit staff complement	Old unit cost per insect (R)	New unit staff complement	New unit cost per insect (R)
E. saccharina	12	0,29	9	0,16
P. claripalpis	3	2,26	3	0,77
X. stemmator	2	7,65	1	0,68
G. natalensis	14	0,43	5	0,24
Washbay	3		3	
Totals	44	10,63	21	1,85

With the mechanisation and resultant modification of many of the routine methods required in insect rearing, made possible by the better facilities provided by the new insect unit, a 50% staff reduction has been effected since 1988. This, in addition to improvements in rearing methods by taking the biology of the insects into account, buying diet ingredients in bulk, and lessening wastage of insects and diets, has resulted in the following cost reductions: 28% in producing one *E. saccharina* individual, 66% in producing one *P. claripalpis*, 91% in producing one *X. stemmator* and 44% in producing one *G. natalensis*.

Discussion

Entomologists list the following as the major problems they encounter when rearing insects in the laboratory, especially when numbers are increased:

- diet contamination by microbes
- differential growth rates
- insect pathogen contamination
- damage to cultures by unwanted parasitoids or mites
- greater mortality with environmental control failures
- space becomes limited

- inconsistencies in rearing output because of reliance on less skilled staff
- little synchrony between insect production and the needs of staff working with the insects (Graham, 1990; Graham and Conlong, 1988; King and Leppla, 1983; Singh and Moore, 1985).

In the Experiment Station's pre-fab insectaries, many rearing operations were completed in crowded conditions in a single room. Literature and experience revealed that the mass rearing aim of reliably supplying good quality insects was impossible in these conditions, and could best be achieved in an insectary where the management of resources such as rearing facilities, personnel and equipment was effectively controlled.

The new insect unit was so designed that many of these shortcomings were eliminated. For example, it was designed as a multi-room facility. This has been especially recommended for rearing Lepidoptera as, in it, one or more staff can work in specialised areas with specific functions (Fisher and Leppla, 1985). Further considerations are given in the February and October 1988 editions of S A Sugar Journal and by Conlong (1989).

A comparison of insect production during the last few months in the pre-fab insectary and what has been achieved in the new unit (Tables 1 to 4) shows that the effort taken in its design and construction was justified. Insect production was increased and became more reliable. Where insect production has subsequently declined, it has been easier to identify the cause and attempt to correct it.

The availability of space and environmental control afforded by the new unit has allowed many of the routine procedures to be mechanised. This has led to increased rearing efficiency, the more economical use of rearing and insect material, and to staff reductions. Since the move to the new unit, savings in production costs, reflected in Table 6, have justified its construction (unpublished data). It is clearly evident that this unit has achieved more than was expected of it in rearing the insects for which it was designed.

However, the performance and success over the last four years of the new insect unit should be judged on its ability to rear the required insects and not by the performance and success of the overall biological control programme against *E. saccharina.* The rearing of promising biocontrol agents for release purposes normally takes place once promising natural enemies of the pest have been found in their land or area of origin, and when biological investigations as to their suitability in the new area have been completed (De Bach, 1964; van den Bosch *et al.*, 1982). This can, by its very nature, be a long term project.

Conclusion

Since its inception, the new insect unit has added value to the Experiment Station's *E. saccharina* control programme, and also to the general knowledge of insect rearing in southern Africa. It continues to be important in supplying insect material for plant resistance studies, pesticide and microbial insecticide bioassays and various aspects of behavioural and ecological research, not only for *E. saccharina* but also for other potential pests of sugarcane.

The commitment of the Experiment Station to more environmentally friendly methods of pest control, as evidenced by the construction of an expensive building solely for the use of insect rearing, endorses the commitment to the environment widely published by the South African Sugar Association.

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REFERENCES

Adkisson, PL, Vanderzant, ES, Bull, DL and Allison, WE (1960). A wheat-germ medium for rearing the pink bollworm. *J Econ Entomol* 53: 759-762.

Anonymous (1988). New building for biological control unit. *S Afr Sug J*: Feb. 1988.

Atkinson, PR (1978). Mass rearing and artificial infestation methods for *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *Proc S Afr Sug Technol Ass* 52: 143-145.

Berger, RS (1963). Laboratory techniques for rearing *Heliothis* species on artificial medium. *US Agric Res Serv [Rep.] ARS-33-84,* 4 pp.

Bottger, GT (1942). Development of synthetic food media for use in nutrition studies of the European corn borer. *J Agric Res* 65: 493-500.

Conlong, DE (1989). Technique development for mass rearing. Proceedings of the First Insect Rearing Workshop held during the Seventh National Congress of the Entomological Society of Southern Africa, pp 10-14.

De Bach, P (1964). *Biological Control of Insect Pests and Weeds.* Chapman and Hall, London.

Fisher, WR and Leppla, NC (1985). Insectary Design and Operation, pp 167-183. *In* Singh, P and Moore, RF (Eds). *Handbook of Insect Rearing, Volume 1.* Elsevier, Amsterdam.

Graham, DY (1990). Development of mass rearing methods for *Eldana saccharina* (Lepidoptera: Pyralidae) 1: Control of fungal contamination on the artificial diet. *Proc S Afr Sug Technol Ass* 64: 116-119.

Graham, DY and Conlong, DE (1988). Improved laboratory rearing of *Eldana saccharina* (Lepidoptera: Pyralidae) and its indigenous parasitoid *Goniozus natalensis* (Hymenoptera: Bethylidae). *Proc S Afr Sug Technol Ass* 62: 116-119.

Ishii, S (1952). Some problems on the rearing method of rice stem borer by synthetic media under aseptic conditions. *Oyo Kontyo* 8: 93-98.

King, EG and Leppla, NC (Eds) (1984). *Advances and Challenges in Insect Rearing.* USDA, New Orleans, 306 pp.

Singh, P (1977). *Artificial Diets for Insects, Spiders and Mites.* Plenum Press, New York.

Singh, P (1988). Insect rearing management (IRM) an operating system for multiple-species rearing laboratories. Abstract for paper presented at Insect Rearing Workshop, International Entomology Congress, Vancouver, Canada.

Singh, P and Moore, RF (Eds) (1985). *Handbook of Insect Rearing, Volume 1.* Elsevier, Amsterdam.

Van den Bosch, R, Messenger, PS and Guttierrez, AP (1982). *An Introduction to Biological Control.* Plenum, New York.

Vanderzant, ES and Reiser, R (1956). Aseptic rearing of the pink bollworm in synthetic media. *J Econ Entomol* 49: 7-10.